

REMARKS

Upon entry of the present amendment, claims 1 and 8 will remain pending in the above-identified application and stand ready for further action on the merits.

Claim 1 has been amended and claim 7 has been cancelled.

The amendments made herein to the claims do not incorporate new matter into the application as originally filed. For example, the amendment to claim 1 regarding the molar ratio finds support in claim 7, which has been cancelled, and in Table 1 on page 15 (i.e., “0.8” at the column of “Epoxy resin/amino curing agent molar ratio”) of the instant specification. The amendment to claim 1 regarding the silane coupling agent is made to clarify that a silane coupling agent is not included in the composition as a separate component (as discussed below) but inorganic filler may be treated with a silane coupling agent. This amendment is made in order to avoid any misunderstanding regarding the scope of claim 1. This amendment is supported by the specification at page 7, lines 32-35.

Accordingly, entry of the present amendment is respectfully requested.

Rejections under 35 U.S.C. § 112, Second Paragraph

At page 2 of the outstanding Office Action, claims 1, 7 and 8 are rejected under 35 U.S.C. § 112, second paragraph based upon the word “type”.

In this amendment, the word “type” has been deleted from claim 1. (However, the scope of claim 1 is not narrowed by the deletion of the term since the term is deleted in order to clarify the present invention.) Thus, each of the rejections has been rendered moot.

Accordingly, Applicants respectfully request that this rejection be withdrawn.

Rejection under 35 USC § 103

At pages 2-3 of the Office Action, claims 1 and 7 have been rejected under 35 USC § 103(a) over JP '120 (JP 64-65120), and further claim 8 has been rejected under 35 USC § 103(a) over JP '120 in view of JP '351 (JP 10-231351). Applicants respectfully traverse.

Reconsideration and withdrawal of each of these rejections is respectfully requested based upon the following remarks.

The Present Invention and Its Advantages

The present invention relates to a liquid epoxy resin composition. The liquid epoxy resin composition can be used, for example, for semiconductor encapsulation which produces a cured product that has improved adhesion to the surface of silicon chips, and especially photosensitive polyimide resins and nitride films, as well as improved toughness.

Specifically, as recited in the claims, the present invention has the features of, for example, “the liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.8/1 to 0.85/1,” “the composition has a toughness K_{Ic} of at least 4.0”, and “(the composition is) free of an alkoxy-bearing silane coupling agent except that an alkoxy-bearing silane coupling agent may be used for the surface treatment of the inorganic filler.”

According to the present invention, the defect which occurs when the temperature of reflow is elevated from the conventional temperature (e.g., approximately 240°C) to 260-270°C can be avoided. Further, deterioration under hot humid conditions as encountered in PCT

(120°C/2.1 atm) can also be avoided. Further, in the present invention, peeling or crack over several hundred cycles of thermal cycling between -65°C and 150°C can be also avoided.

In short, the presently claimed liquid epoxy resin composition is effectively adherent to the surface of silicon chips and especially photosensitive polyimide resins and nitride films, and is not deteriorated under hot humid conditions as encountered in PCT (120°C/2.1 atm), and is fully resistant to thermal shocks. The composition is thus well suited as an encapsulant for large die size semiconductor devices.

When the epoxy resin and the aromatic amine curing agent of formulae (1) to (3) are used in a molar ratio of 0.8 to 0.85, as recited in claim 1, the liquid epoxy resin composition has a toughness K_{Ic} of at least 4.0, and becomes effectively adherent to the surface of silicon chips, especially photosensitive polyimide resins and nitride films. Subsequently, significant resistance to thermal shocks can be obtained, and desired properties can be maintained even under hot humid conditions.

In general, the prior art compositions contain not only an epoxy resin and amine curing agent, but also a silane coupling agent as an essential component. However, the silane coupling agent causes voids when the resin compositions are poured or cured for the manufacture of flip chip semiconductor devices. In the present invention since a silane coupling agent is not contained, the composition of the present invention does not have such a problem and is highly reliable and effective as an encapsulant especially for large die size semiconductor devices.

Further, the present invention has unexpected results, which are explained and fully proved by the Examples of the present specification as well as the Declaration of Mr. Kazuaki

Sumita (the Sumita Declaration) filed on January 23, 2006 (a more specific explanation is provided below).

Distinction over JP '120 (JP 64-65120)

JP '120 discloses a liquid epoxy resin composition comprising an aromatic amine.

However, JP 64-65120 fails to disclose or suggest "the liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.8/1 to 0.85/1" (i.e., $A/B=0.8/1$ to $0.85/1$) and "the composition has a toughness K_{1c} of at least 4.0".

At most, at Example 1 of JP '120, it is disclosed that the curing agent is "diaminodiphenylmethane:metaphenylene diamine = 4:6," and is used in an equivalent amount to the epoxy resin. Accordingly, the molar ratio of the epoxy resin to diaminodiphenylmethane is more than 1.

Therefore, JP '120 fails to disclose or suggest the present invention.

Distinction over JP '351 (JP 10-231351)

JP '351 merely discloses a liquid injection sealing underfilling material comprising a liquid epoxy resin, a curing agent such as alkylated diaminodiphenylmethane, and a spherical filler.

At most, at Examples 1 to 3 of JP '351, 100 parts by weight of liquid epoxy resins and 35 parts by weight of the curing agent "*8" in the form of alkylated diaminodiphenylmethane of an equivalent of 65 are used (see paragraph 0015 of JP '351). Therefore, the epoxy resin is contained in a larger amount as compared with the curing agent (i.e., A/B is much higher than 1).

Moreover, in JP '351, the epoxy resin composition of all of Examples 1 to 7 as well as Comparative Examples 1 to 7 contain coupling agent, which is not contained in the present invention, as recited in claim 1.

As shown at Comparative Example 6 of Table A of the Sumita Declaration, the silane coupling agent contained a composition which would cause voids.

Since a silane coupling agent is not contained in the present invention as a separate component, the present invention is clearly distinguished from JP '351. Moreover, with respect to JP '351, the epoxy resin includes 5-30 wt% of an epoxy resin of formula I. On the other hand, the epoxy resin according to the present invention consists of a bisphenol epoxy resin. JP '351 fails to disclose the use of the epoxy resin consisting of a bisphenol epoxy resin.

Accordingly, JP '351 fails to disclose or suggest the features of the present invention (e.g., "the liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.8/1 to 0.85/1," "the composition has a toughness K_{Ic} of at least 4.0," and "the composition is substantially free of an alkoxy-bearing silane coupling agent except that an alkoxy-bearing silane coupling agent may be used for the surface treatment of the inorganic filler."

Combination of the Cited References

A *prima facie* case of obviousness is not established even if the cited references are combined since none of the cited references disclose or suggest the feature of the present invention (e.g., "the liquid epoxy resin (A) and the aromatic amine curing agent (B) are present in a molar ratio (A)/(B) from 0.8/1 to 0.85/1," "the composition has a toughness K_{Ic} of at least

4.0,”) which is recited in claim 1. Likewise, it follows that a person having ordinary skill in the art would not be motivated by any of the teachings of the cited references to arrive at the present invention.

Accordingly, the cited art does not provide any motivation to arrive at the instant invention as claimed, and moreover the instant invention possesses unexpected (as discussed below) and advantageous properties not rendered obvious by the cited art.

Unexpected Results

Further, the present invention has unexpected results, as proved by Examples of the specification and the Sumita Declaration. For the Examiner's assistance, modified Table A is shown below, which was prepared based upon Table A of the Sumita Declaration, is proved below. For example, as shown in the Sumita Declaration, when the molar ratio of the liquid epoxy resin (A) and the aromatic amine curing agent (B) is 0.8/1 to 0.85/1, the toughness K_{Ic} is at least 4.0. On the other hand, if the molar ratio of the liquid epoxy resin (A) and the aromatic amine curing agent (B) is out of the inventive range, the toughness K_{Ic} is less than 4.0. That is, if the molar ratio of the liquid epoxy resin (A) and the aromatic amine curing agent (B) is out of the range such as a 0.7/1 and 0.9/1, the toughness of K_{Ic} is less than 4.0, as is shown in Table 1 of the present specification and Table A of the Declaration.

Further, as explained above, since a silane coupling agent is not contained in the composition of the present invention, the generation of voids can be avoided (see Comparative Example 6 of the Sumita Declaration).

Further, as explained above, in the both cited references, the ratio “A/B” is more than 1. Therefore, even if the cited references are properly combinable, they do not suggest the claimed A/B ratio (i.e., 0.8/1 to 0.85/1). As shown in Comparative Examples 4 and 5 in the Sumita Declaration (see also below Table), when the ratio “A/B” is 1, 5 failures were observed at the thermal heat shock test (750 cycles). However, the ratio “A/B” is less than 1 (e.g., 0.8), no failures were not observed in the Sumita Declaration.

From the specific data of the thermal heat shock test, it is also clear that the present invention (e.g., Examples 1, 7 and 10 in the Sumita Declaration) has advantages, compared to the cited references, in which “A/B” is more than 1.

Modified Table A

Component (pbw)		Example							Comparative Example		
		1	6†	7	8†	9†	10	11†	4	5	6
KBM403 (Silane Coupling Agent)											1.0
Epoxy resin/amine curing agent molar ratio (A/B)		0.8	0.7	0.8	0.9	0.7	0.8	0.9	1.0	1.0	0.8
Measurement results											
Void test		nil	nil	nil	nil	nil	nil	nil	nil	nil	voids
Toughness K _{IC} (MPam ^{2/1})		4.3	3.9	4.2	4.1	3.8	4.0	3.8	3.3	3.4	4.4
Failure (%) after thermal shock test	750 cycles	0	0	0	0	0	0	0	5	5	0

† Examples 6, 8, 9 and 10 are Comparative Example because of the current amendments to claims 1.

Accordingly, the present invention (claim 1 and dependent claims 7 and 8) are neither anticipated by nor obvious over the cited references.

CONCLUSION

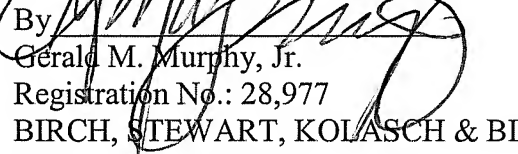
Based upon the amendments and remarks presented herein, the Examiner is respectfully requested to issue a Notice of Allowance clearly indicating that each of the pending claims 1 and 8 are allowed under the provisions of Title 35 of the United States Code.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Gerald M. Murphy, Jr. (Reg. No. 28,977) at the telephone number below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37.C.F.R. §§1.16 or 1.14; particularly, extension of time fees.

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Respectfully submitted,


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